Astronomical Telescope

User Guide

WARNING!!

Never point the telescope directly at or near the Sun at any time. Observing the Sun, even for a fraction of a second, will result in instant and irreversible eye damage. Please ensure minors are supervised by an adult conversant with this real danger when using telescopes or binoculars.

OVL

OPTICAL VISION LIMITED

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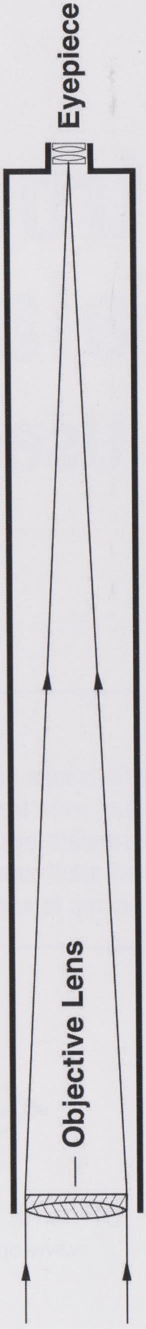
Types of Telescope...

Of all the many and varied telescopes available for use by amateur astronomers and nature watchers, all can be categorised into three types: the refractor, the reflector & the catadioptric. Each have their relative strengths and weaknesses, but they all have a common function: to gather and focus light from distant objects to produce a bright image that may be magnified. In this respect it is the aperture (i.e. the diameter of the main mirror or lens) of the telescope that performs a critical function. With larger apertures, more light is gathered so fainter objects may be perceived and the resolving power (i.e. the ability to see fine detail) is increased.

When comparing telescopes of similar type but of differing apertures, an instrument that has a main lens or mirror twice the size of another gathers four times as much light, not twice. We are comparing the collecting areas of the larger and smaller telescopes, which is proportional to the squares of the apertures. So, for example, a 120mm telescope gathers 2.25 times (225%) as much light as an instrument of 80mm aperture (120/80 = 1.5, 1.5 squared = 2.25).

When it comes to seeing fine detail in an image, we are simply comparing apertures: a 120mm telescope will enable you to perceive lunar craters, for example, half the size of those visible in a 60mm instrument. No amount of magnification applied to the smaller telescope will show you that which will be visible in the larger instrument, though both images may appear equally sharp. The larger telescope merely forms its images out of smaller 'dots'.

However, the resolving power (as it is correctly termed) of even the smallest telescope is awesome: a 60mm telescope is capable of resolving detail as small as a £1 coin at a distance of 2.35 km - nearly 1.5 miles!



< The refractor:
This is the type of instrument that the layman thinks of when conjuring up a mental picture of a telescope.

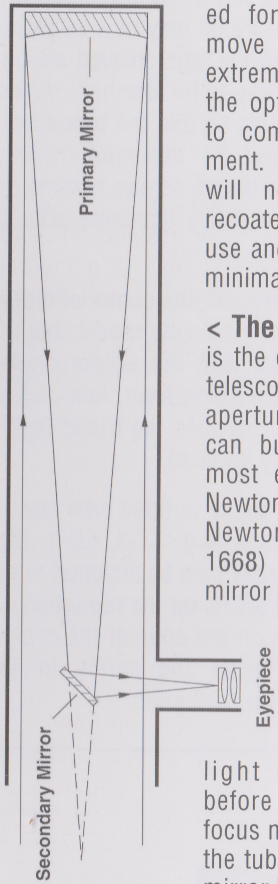
At the end of the tube furthest away from the observer there is an objective lens (or rather two glass elements sandwiched together for reasons to be explained in a moment) that gathers light from the object under scrutiny, to form an image at the other end which is viewed by means of an eyepiece.

The objective lens cannot be made of a single piece of glass since such an element is incapable of bringing light of differing wavelengths to a common focus, introducing a prismatic effect that causes bright objects to be surrounded by false rainbow colours.

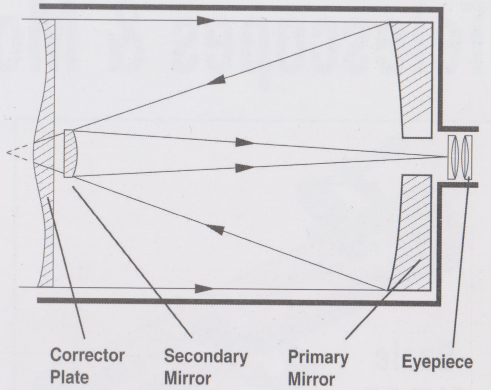
This undesirable quality of refractors is virtually eliminated by making the objective out of two glass elements with optical characteristics that effectively 'cancel out' the false colour.

Consequently, an objective lens is a piece of optical equipment that is difficult to manufacture and explains why refractors are the most expensive form of telescope, aperture for aperture. However, a refractor can deliver exquisite images that are very well corrected and extremly high in contrast, suitable for observing fine lunar and planetary detail, or for separating difficult double stars.

Refractors are well suited for people on the move since it is extremely difficult for the optical components to come out of alignment. Also, the lenses will not need to be recoated in a lifetime's use and maintenance is minimal.



< **The reflector:** This is the cheapest form of telescope, aperture for aperture, that money can buy. In the form most encountered, the Newtonian (after Isaac Newton's design in 1668) uses a concave mirror at the base of the tube to gather and focus the light from the object under scrutiny. The light is intercepted before coming to a focus near the mouth of the tube by a small, flat mirror inclined at 45° to the optical axis which relays the image out of a hole in the side of the tube to a waiting eyepiece that magnifies the image in the normal fashion. Since the light is not refracted in any way, and a mirror reflects light of all colours equally, there is no false colour from a reflecting telescope.



^ The catadioptric:

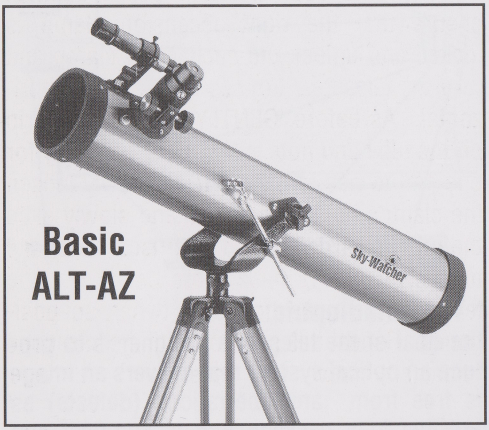
The goal of the telescope designer is to produce an optical system that delivers an image as free from any aberrations (defects) as possible in a package that is compact and manageable. This has led to designs incorporating both reflecting and refracting elements to produce an instrument that combines the best attributes of both systems.

Thus, we now see many commercial telescopes similar to the Maksutov-Cassegrain system illustrated above that packs a long focal length into a physically short tube, while preserving the high-contrast imagery associated with refractors of the same aperture.

Catadioptric variations of the Newtonian telescope are currently very much in vogue, offering compact tube assemblies with convenient viewing positions. Since these systems often have optical windows sealing the end of the tube (which would otherwise be open in a conventional Newtonian), the internal optical components are far better protected from the elements and dust.

Remember that no particular design of telescope is intrinsically better than another – each is well suited to a wide variety of observational subjects. The important consideration is that the optics should be accurately manufactured and be precisely collimated (aligned).

Telescopes & Mounts...



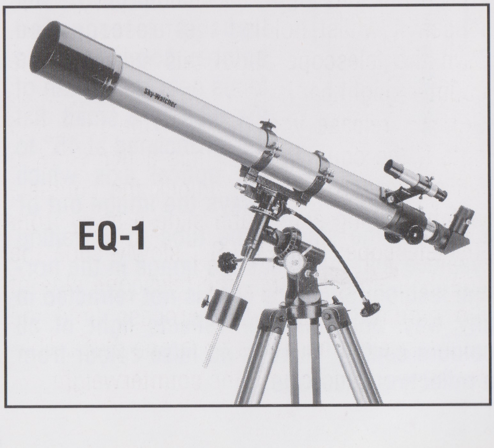
Of all the many and varied telescopes available for use by the amateur astronomers, the mountings that support them fall into two types - the alt-azimuth and the equatorial. The 'Using your telescope' section of this booklet that follows will tell you more about these terms and the actual use of your instrument, so we will concentrate on the actual initial assembly and adjustments of your telescope here.

The initial assembly of your telescope is best undertaken in daylight with plenty of room to lay out the components and to familiarise with the accompanying images to see how the assembled instrument should look.

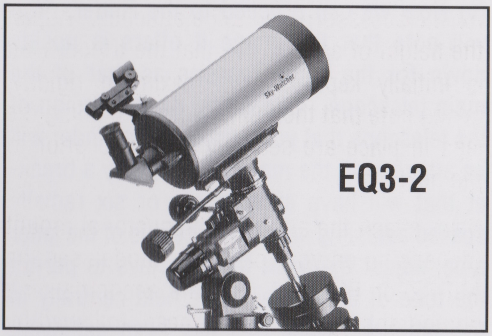
The three legs should be attached to the tripod head one by one by the three bolts and wing nuts provided. They should not be overtightened, but just made finger tight. Pay particular attention to the orientation of each leg prior to assembly such that the tripod tray bracket is facing inward. The tripod may now be placed on the ground with the legs splayed enough for the accessory tray to be attached. Adjust the height of each leg so that the tripod head is initially kept low for maximum rigidity, taking note that the thumb screws holding the legs in place are securely tightened prior to the next stage.

Next, attach the alt-azimuth/equatorial mount (depending on your particular model: see the ALT-AZ or EQ label with the accompanying photographs) to the tripod head, followed by the accessory tray between the tripod legs if you haven't already done so.

If your telescope mount is fitted with flexible slow motion controls (e.g. AZ-3, EQ-1, EQ2 and EQ3-2) these may now be attached to the two small chrome shafts on the mounting via the thumb screws on the ends of the cables, taking care to locate the screw in the machined 'notch' on each shaft.



EQ-2



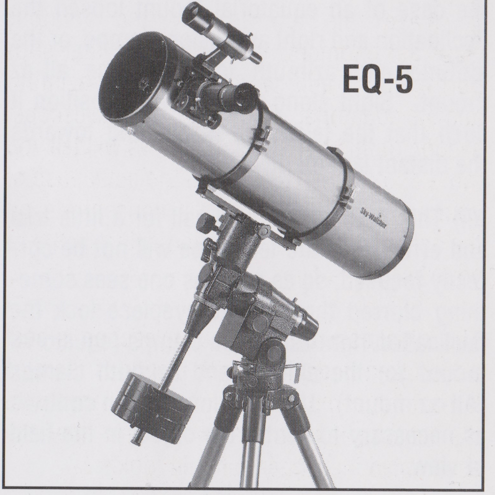
EQ3-2

Balancing the Telescope: To eliminate stresses on the EQ equatorial mounts and to ensure smooth, judder-free motion of the telescope the instrument needs to be balanced about both the declination and polar (right ascension) axis. This is especially important if you propose to use a motor drive for astrophotography at a future date.

(i) Locate the right ascension clamp and loosen it whilst holding the telescope tube. Turn the telescope about this axis until the counterweight bar is approximately horizontal. GENTLY release your grip on the tube and note if the counterweight has a tendency to fall or rise: if it RISES, unlock the counterweight locking screw and slide it away from the telescope; if it FALLS , slowly slide the counterweight towards the telescope side of the mount. Repeat this process until the counterweight bar remains in one place without support and clamp the counterweight screw firmly - the telescope is now balanced about the polar (right ascension) axis.

(ii) With the counterweight bar horizontal, ensure that the right ascension clamp is locked and unlock the declination clamp and turn the telescope tube so that it is also horizontal. As before, GENTLY release your grip on the tube and note is there is a tendency for one end to rise in the air. If so, slowly loosen the clamps holding the tube and slowly slide the tube towards the end that rises. Lock the tube clamp rings once more and see if the telescope remains horizontal when so positioned. Repeat this process until the telescope remains wherever you place it.

The telescope is now balanced about both the declination and polar (right ascension) axes, In due course you will add various accessories to the telescope that will slightly alter the balance position particularly if it is a camera for astrophotography) in which case you will have to go through processes (i) and (ii) again, but for now you may care to mark the balance points on the counterweight bar and the telescope tube with small pieces of tape for fast assembly in future.



EQ-5

Attaching the finderscope:

An essential prerequisite for the easy location of objects on both land and in the sky is the correct location and alignment of the finder-scope that attaches to the tube of the tele-scope. It is, in fact, a smaller version of the main telescope that is designed to have a low magnification and a wide field of view so that the desired target may be easily located. The eyepiece of the finder scope is equipped with cross-hairs much like a gun sight marking the centre of the field of view.

Aligning the finderscope:

(i) Setup the telescope on its mount outdoors in the day time and ensure that it is balanced as previously described. You may wish to extend the tripod legs and securely lock them again once you have the telescope at a com-fortable working height. Enlisting the help of a friend will aid this process. Select the lowest magnification eyepiece in the set (this is the one with the largest number engraved on the cap: usually 20mm or 25mm) and place it in the focuser drawtube as previously described.

(ii) Select a distant prominent object such as the tip of an electricity pylon or the tip of a church spire, though any distant, well-defined object will do: the further away the better. In the case of an equatorial mount loosen the declination and right ascension clamps, or the altitude and azimuth locks on the alt-az mount. Sight along the tube and position it such that the telescope is pointing towards the distant landmark.

(iii) This first attempt will call for a little trial and error since the telescope will not be cor-rectly focused, so as soon as one sees some-thing blurred through the eyepiece lock the declination/right ascension clamps (equatorial mount)or the altitude and azimuth clamps (Alt-az mount). Use the slow motion controls as necessary to centre the object in the field of view.

(iv) Turn the focuser knobs back or forth until the image becomes crisp and sharp. Do not be concerned that the image appears upside down (reflecting telescope) or reversed in a left to right plane (refractor with zenith prism) - this is perfectly natural for an astronomical telescope since there is no 'up' or 'down' in the sky and you will soon get used to it. With the image correctly focused you may wish to use the slow motion controls to perfect the alignment on the distant target.

(v) Now we can proceed to the Finder. You will note that the image it offers is upside down for the same reasons as that of the main telescope. Depending on the design of the telescope that you possess, the Finder will be attached to the main telescope by a brack-et that will have either three or six radially spaced adjusting screws: if yours is of the latter type, adjust the front three screws to permit the tube of the Finder to be held centrally in the bracket. Once this has been achieved, check that the target is still central to the field of view of the main telescope then slowly adjust the rear three screws of the finder bracket until the same object is positioned in the centre of the cross-wires in the finder's eyepiece. Again it may help to have a friend to help you with this procedure. Once achieved, ensure that the lock nuts of the Finder adjust-ing screws are secure. Now you can loosen the locks on the polar (/azimuth) and declina-tion (/altitude) axes and practice locating objects during the day.

Telescope basics:

Calculating the telescope's magnification

The magnifying power of any given telescope and eyepiece is given by a simple formula that requires a knowledge of the instrument's focal length and that of the eyepiece. As we have seen, the focal length of an eyepiece is usually engraved on its cap: 10mm or 25mm, for example.

The focal length of the telescope is usually given on a label near the eyepiece focuser and is the distance from the main lens or mirror to the point at which it forms an image of a distant object. The magnification of any given telescope/eyepiece combination is given thus:

$$\textbf{Magnification} = \frac{\textbf{focal length of telescope}}{\textbf{focal length of eyepiece}}$$

For example, a telescope with a focal length of 1000mm used in conjunction with a 7.5mm eyepiece would yield a magnification of 133x (1000÷7.5 and rounded to the nearest whole number), whereas the same instrument used with a 20mm eyepiece would deliver 50x. It follows that the larger the focal length of the eyepiece, the lower the magnification it will deliver with any given telescope.

Why do we need to use eyepieces of differing magnification? Apart from making the image of the subject larger or smaller, magnification has a bearing on the area of sky (termed the field of view) that is visible: Higher magnifications have smaller fields of view, which can make finding objects that much more difficult (especially if your Finder is not correctly aligned) - another reason for spending some time in daylight perfecting the process as outlined above.

The field of view in degrees may also be obtained by another simple formula which is valid for most types of eyepieces commonly found in amateur hands, thus:

$$\textbf{Field of view (degrees)} = \frac{\textbf{42}}{\textbf{magnification}}$$

Again, for example, a telescope with a focal length of 1000mm using a 15mm eyepiece will deliver a magnification of 67x which, using the formula above, will give a field of view of 0.63 degrees.To give you some idea of scale, the Full Moon is almost exactly 0.5 degrees in diameter, so our telescope/eyepiece example would enable us to display the whole of the Moon's disc within the eyepiece's field of view.

How many eyepieces should you have? Three is ideal - one low, one medium and one high magnification - though two will suffice at a pinch. A low magnification of 30-50x is advisable for observing star clusters, galaxies and nebulae since they are often spread over a wide area of sky. Medium magnifications of 80-100x are convenient for studying the craters and valleys of the Moon's surface, seeing the rings of Saturn or Jupiter and its four principal moons. Higher powers of 150-200x will permit you to scrutinise mountain peaks and fine lunar detail, the surface features of Mars or to separate close double stars.

You can buy other eyepieces to increase the versatility of your telescope, or you may care to purchase something known as a Barlow lens that is inserted into the focusing tube before the eyepiece which doubles the magnification - a good way of getting double the performance out of each eyepiece!

As you get more proficient at observing you will come to appreciate that merely adding more magnification is useless unless the atmospheric conditions are steady enough to permit their use. On many nights the air may appear steady to the naked eye, but in the telescope the image of a bright planet such as Jupiter or Saturn will appear to shimmer, or the edge of the Moon may appear to ripple; these are the nights of so-called 'poor seeing'.

Even on a night of steady air a good general rule to employ is that you will be approaching the practical limits of your instrument on most nights when the magnification exceeds twice the aperture of your telescope in millimetres: this means that the maximum working power of an 80mm aperture instrument will be in the region of 160x, or 300x for a 150mm telescope.

Using your telescope...

Depending on the type of telescope mount that you possess, there are two ways in which you can move the instrument in order to locate and track objects in the sky. I stress 'track' here since, unlike viewing stationary terrestrial objects, the rotation of the Earth on it's axis once in 24 hours from west to east causes the sky to make one revolution about the celestial poles in the same period (incidentally, if you have not yet familiarised yourself with the 'Get to know the sky' section of this booklet, now might be a good time to familiarise yourself with some of the concepts contained within it).

The Alt-azimuth mount: this is the the simplest type of telescope mounting to understand and, in some senses, to use. There are variations that I'll discuss in a moment, but all share the common characteristic that there are two axes about which the telescope can be moved which are perpendicular to one another (see Fig.1, page 10). The first axis permits the telescope tube to be moved from horizontal to vertical and is known as the 'altitude' axis. the second allows the instrument to be moved in an arc parallel to the horizon through a complete 360° circuit of the compass; this is the 'azimuth' axis. So, a mounting permitting motion about both such axes is called an 'alt-azimuth'.

In its most basic form, there is usually a 'slow-motion' control in the form of a threaded rod that is operated by a thumbwheel permitting precise control of the telescope's tube in altitude. On more sophisticated mounts (such as the AZ-3 model) there is provision for slow motion controls in both altitude and azimuth — this makes for much finer control when tracking celestial objects at high power.

Alt-azimuth conventions: As has been discussed elsewhere, looking up at the night sky gives the impression that the observer is at the centre of a vast hemisphere — the so-called 'Celestial Sphere'. The stars, Moon and planets all appear to lie on the inside surface of this hemisphere an infinite distance from the observer. This is, of course, an illusion since the Moon and stars are in reality at greatly differing distances away from us. However, the Celestial Sphere concept has its advantages in that it makes it easy to define coordinates for objects in the sky and to predict where a given star or planet will be at any given time.

Looking at Fig. 1 once more, note that the portion of the Celestial Sphere shown in the diagram has been divided up by lines and arcs in much the same way as the surface of the Earth has been divided up into latitude and longitude. By careful observation you will note that the star Polaris which resides in the constellation of Ursa Minor (the Little Bear) always appears stationary above the northern horizon at an angle very close to that of the observer's latitude. This is because Polaris is very close to the northern celestial pole and all the other stars appear to circle around it in a counter-clockwise direction once every 24 hours. Lying close to due north means that Polaris will always have an Azimuth bearing close to zero, or 0°. For an observer in the British Isles its Altitude bearing will lie between 50° and 55°.

The further that one moves across the sky from Polaris, the apparent motion of the stars becomes more evident and their Altitudes and Azimuths will be continually changing. Taking

the star labelled 'AA' in Fig. 1, at the instant of the observation its Altitude was 60° and its Azimuth bearing was also 60°. It can be seen that Azimuths are measured in degrees from due north (0°) through east (90°), south (180°), west (270°) and back to north (360° or 0°). Altitudes are measured in degrees over a maximum range of 90 — objects exactly on the horizon are at 0° and those overhead are at 90° (it is possible to have Altitudes of negative sign, but this means that the object is below the horizon and therefore invisible).

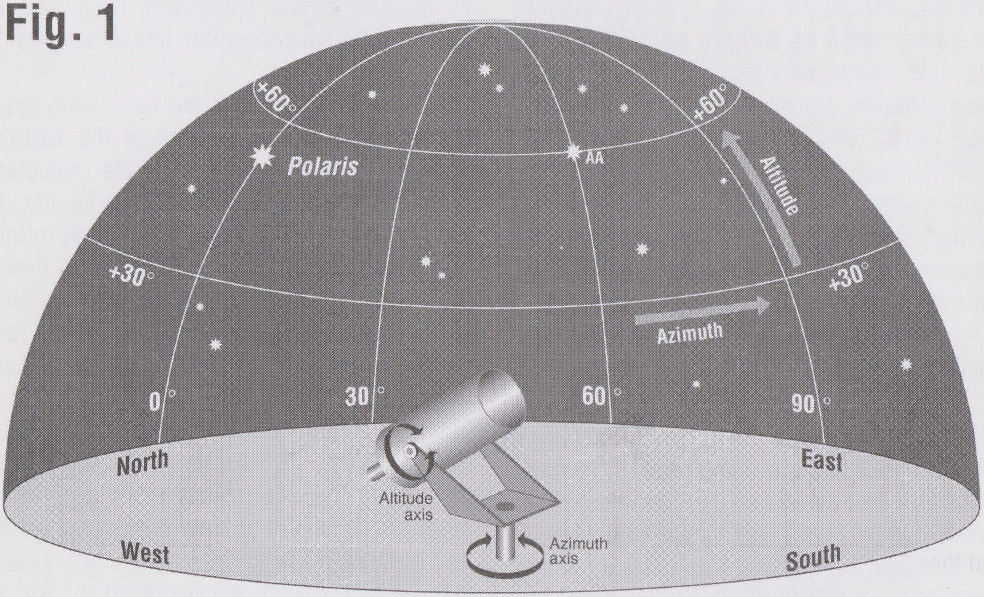
The continual changing of Altitude and Azimuth as a celestial body rises in the east, traverses the sky and sets to the west makes tracking an object at high magnifications quite a challenge, but it is surprising how soon one becomes proficient at doing so. However, should the observer wish to attempt any form of time exposure with the telescope to photograph a faint galaxy, for example, then a different type of instrument mounting known as an Equatorial is required.

The Equatorial mount: the equatorial mount consists of two axes that lie perpendicular to one another (as per the Alt-azimuth system), but one is tilted such that it is aligned parallel to the Earth's axis, which means for observers in the northern hemisphere one axis will always point close to Polaris in the northern sky — not surprisingly, this is termed the Polar Axis. As depicted in Fig. 2 on page 11, the Equatorial is the mounting of choice if any form of astrophotography is envisaged. It also makes the process of prolonged tracking so much easier since the telescope can be motorised about the Polar Axis such as to automatically follow the Moon, planets and stars in their diurnal paths across the sky.The so-called declination axis can remain locked once the desired object has been located. Unlike the Alt-azimuth system, the coordinates of objects remain (relatively) fixed and a slightly different convention has to be used.

Equatorial conventions: the coordinate system is based on projections of the Earth's gridwork of latitude and longitude projected onto the Celestial Sphere. Consequently, a star such as Polaris that lies very close to the northern celestial pole would be always overhead for an observer on the North Pole, whereas a star such as that labelled 'BA' which lies 90° away from Polaris will be overhead at some point for an observer on the Earth's equator. This is known as the star's Declination and varies from +90° near Polaris to -90° at the opposite celestial pole. The other coordinate is termed Right Ascension and is measured in hours from 0 to 24. Thus, star BA has a Right Ascension of 2h and a declination of 0°.

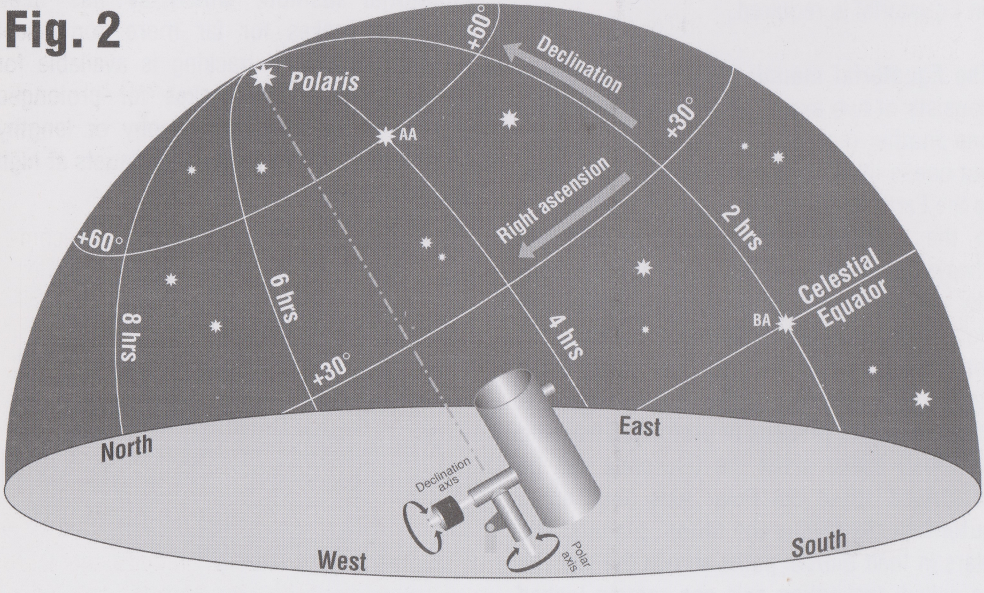
All telescopes in the Helios range designed for prolonged and serious use are mounted in the Equatorial fashion, which as has been described makes for far more convenient viewing. Motorised tracking is available for most models which makes for prolonged exposures for astrophotography or lengthy observations of the Moon and planets at high magnifications.

Fig. 1



Understanding the 'Alt-az' system...

Fig. 2



Understanding the 'Equatorial' system...

The equatorial mounting...

Setting up and using an equatorial mount

The Earth's eastward rotation causes stars to apparently rotate around a point in the sky which is a projection of the Earth's axis, called the celestial pole. A star's path through the sky from an earthbound observer's viewpoint is therefore an arc of this rotation; it rises in the east towards its highest altitude (on the local meridian - directly south) and then sets in the west. It does not travel in a line parallel to the horizon. (Except at the north pole, from where the celestial pole is at the zenith!)

Telescopes are generaly provided with one of two basic designs of mountings. The so called alt-az allows a telescope to move in altitude (up/down) and azimuth (left/right). This does not allow easy tracking of a star's curved path through the sky since an alt-az has to move in a series of vertical and horizontal steps, which for the purpose of steady observation, are cumbersome.

In the Equatorial, the alt-az mounting is in effect tipped at an angle, provision being made for the azimuth axis to be aligned to the Earth's rotational axis (towards the celestial pole). This allows a telescope to follow a star by simply countering the Earth's rotation in one motion, rather than the combination of two movements which would be necessary with an alt-az. A motive force, either manual or motorised, applied to what we must now call the 'polar' axis, is all that is necessary to track a star through the sky.

In order for this action to follow a star without deviation the polar axis of the equatorial mounting must be very accurately aligned on the celestial pole. The better this is done, the less requirement there will be for minor adjustments during observation.

Polar axis alignment

(approximate setting)

Try to carry out polar axis alignment on a level surface, where the location of the tripod (or pillar) feet can be permanently recorded to allow the telescope to be placed in exactly the same position for subsequent observations. If a choice of observing location is limited, try to position the telescope for the best view of the southern sky as possible.

Adjust the angle on the latitude scale of the polar axis, shown in **figure 1**, until this equates to your latitude (previously determined from an OS map).

For the sake of ease and safety, it is recommend that the telescope and its counterweights be removed from the mounting for this exercise.

The polar axis itself should then be aligned north-south, with its upper end facing true north. (Not magnetic north!) An approximate heading can be obtained by sighting along the polar axis so that it points towards Polaris.

With such approximate alignment, the telescope should be able to track objects with only occasional corrections on the declination axis.

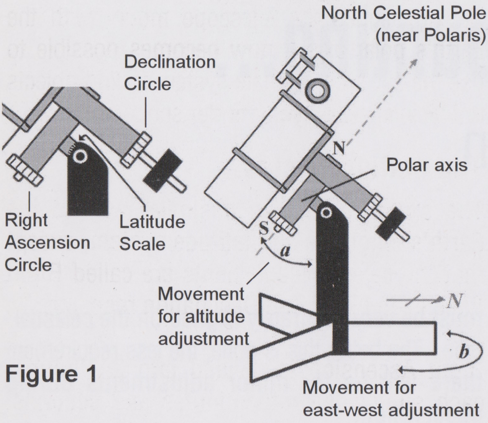


Figure 1

Polar axis alignment
(precise setting)

The following process will allow tracking without the need for occasional corrections, and is essential if photography using a motorised drive is envisioned. If the approximate alignment described above has been carried out correctly, only very minor adjustments in azimuth (north-south line) and polar axis elevation are now required. These need to be carried out via observation of a star through the telescope.

Polar axis elevation
(altitude) alignment

Choose a bright star in the east and locate in the eyepiece field. Establish the current axial motion of the telescope by gently moving the telescope tube back and forth, (rotating east-west on the polar axis only as shown in **figure 2a**) so that the star is impelled to move from one side of the eyepiece field to the other. It will help if you arrange this line of motion to bisect the eyepiece field (as in **figure 2b**).

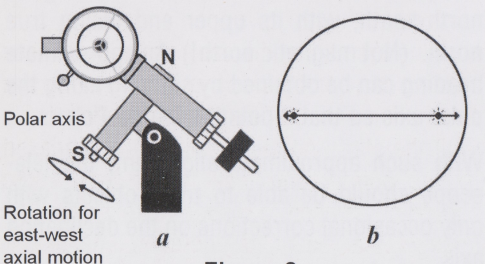


Figure 2

This procedure can be made easier if a reticle is placed at the eyepiece focus and aligned to indicate this motion, rather than having to remember it in the mind's eye.

The reticle can be a rolled piece of cardboard, joined by sticky tape, of such a diameter that it snugly fits into the inner barrel of the eyepiece. A hair or thread is fastened across one end of this cardboard tube, approximately bisecting it (**figure 3a**). A cross hair reticle may already be supplied with your instrument (**figure 3b**).

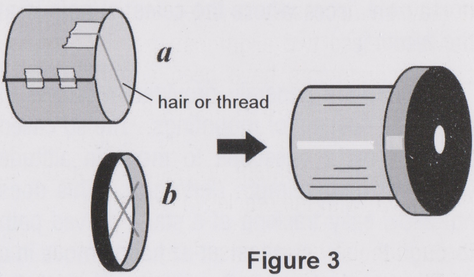


Figure 3

Holding the eyepiece up to the light, it should be possible to insert the reticle until the filament comes into focus. (Note. The insertion of a reticle is only possible with certain eyepiece designs.) The filament, or one of the cross hairs, can then be aligned (by turning the eyepiece) to establish the direction of axial movement as required (as in **figure 4**).

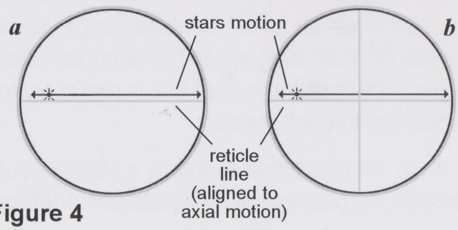


Figure 4

Once this line of axial movement has been established, set the star at the edge of the field and allow it to drift across via its own motion. If the star drifts upwards from this line (**figure 5a**), then the north end of the polar axis needs to be raised. If the star drifts below this line (**figure 5b**), the north end of the polar axis needs to be lowered.
This altitude adjustment is shown in **figure 1a**.

Polar axis (azimuth) alignment

Now observe a star in the south and repeat the preceding observation exercise. This time, an upward drift (**figure 5a**) indicates that the north end of the polar axis should be shifted west; if the star drops (**figure 5b**), the shift should be east. This azimuth adjustment is shown in **figure 1b**.

It may be necessary to alternate a few times between these two alignment exercises. Once these adjustments have been completed successfully, a star allowed to drift across the field should run parallel to the line established by manual axial movement, to point c in **figure 5**. (As shown with the reticles in **figure 4**.)

It cannot be emphasised enough that the additional adjustments made should be slight and as the correct alignment is approached the tell tale deviations will become harder to detect.

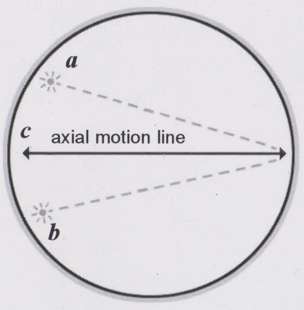


Figure 5

Having aligned the telescope mount with the Earth's polar axis it now becomes possible to use the sky's co-ordinate system to find objects not visible to the eye or finder scope.

The setting circles

The sky is plotted in a similar way to the Earth's longitude and latitude system, except that the celestial equivalents are called Right Ascension (R.A.) and Declination respectively.

Right Ascension is divided into 24 'hours', each subdivided into minutes and seconds. Declination is measured in degrees, commencing with +90° at the north celestial pole (towards which the telescope's polar axis points, for northern observers) decreasing to 0° at the celestial equator.

Below the celestial equator, declinations are designated as minus, rising from 0° to -90° at the south celestial pole.

Calibrating the declination circle.

In order to use the equatorial mount's declination scale effectively, the declination circle needs to be fixed so that pointer indicates +90° when the telescope is aimed at the celestial pole.

Use the telescope at its highest power to observe a star whose declination is known. (All good star atlases should have this information available. In lieu of such a source, a list of bright stars easily found in a star map appears in the appendix.)

Keeping the star in the centre of the eyepiece field, loosen the locking mechanism of the declination circle. Turn the declination circle until the star's correct declination is indexed by the pointer and lock the circle. There should be no need to repeat this exercise - so long as polar axis alignment is maintained.

Using the setting circles

(The following applies to telescopes using a single index on the R.A. circle)

The easiest way to use setting circles is to off-set from a known position. Set the telescope on an object whose position is known (i.e. a bright star in a recognisable constellation - such as listed in the appendix). Unclamp and turn the R.A. circle so that the its pointer indexes the observed object's positional hour and minute. E.g. In **figure 6**, the R.A. circle has been set to indicate that the initial object has a listed position of 5 hours 40 minutes. (The declination circle should read the object's declination correctly if the polar axis alignment has been maintained.) It is now only necessary to move the telescope in both axes until the R.A. and Declination pointers index the new object's position.

E.g. In **figure 7**, the telescope has been moved to a new object having an R.A. of 7 hours 30 minutes. If the 'target' is not visible, delicate 'sweeping' with a low power eyepiece should bring it into view.

Figure 6

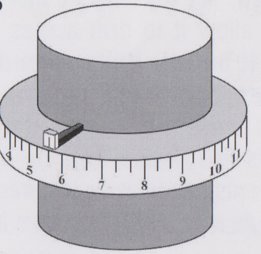
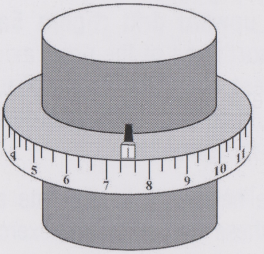


Figure 7



Appendix

Most good star atlases will list the R.A. and Dec. co-ordinates of the principle stars and interesting objects within each constellation. Below is a list of easily found stars, at least one of which should be visible at any one time for use as starting points.

Constellation	Star	Right Ascension	Declination
Spring			
Bootes	Arcturus (α Boötis)	14h 13.4m	+19° 27'
Virgo	Spica (α Virginis)	13h 22.6m	- 10° 54'
Leo	Regulus (α Leonis)	10h 05.7m	+12° 13'
Summer			
Aquila	Altair (α Aquilae)	19h 48.3m	+8° 44'
Cygnus	Deneb (α Cygni)	20h 39.7m	+45° 06'
Lyra	Vega (α Lyrae)	18h 35.2m	+38° 44'
Autumn			
Perseus	Algenib (α Persei)	3h 20.7m	+49° 41'
Cassiopea	Schedir (α Cassiopeiae)	0h 37.7m	+56° 16'
Pegasus	Markab (α Pegasi)	23h 02.3m	+14° 56'
Winter			
Canis Major	Sirius (α Canis Majoris)	6h 42.9m	-16° 39'
Orion	Betelguese (α Orionis)	5h 52.5m	+7° 24'
Auriga	Capella (α Aurigae)	5h 13.0m	+45° 57'
Taurus	Aldebaren (α Tauri)	4h 33.0m	+16° 25'

Tips on observing with your telescope...

With the telescope assembled, balanced and polar-aligned as described previously, you are ready to begin observations. Decide on an easy to find object such as the Moon, if visible, or a bright star to become accustomed to the functions and operations of the telescope. For the best results during observations, follow the suggestions given as follows:-

● To centre an object in the main telescope, loosen the telescope's R.A. and DEC locks. The telescope can now turn freely on its axes. Use the aligned viewfinder's crosshairs and re-tighten the R.A. and DEC. locks.

● If you have purchased an assortment of eyepieces, always start an observation with a low power eyepiece (e.g. a 20mm or 25mm eyepiece). Get the object well centered in the field of view and sharply focused. Then try the next step up in magnification. If the image starts to become fuzzy as you increase magnification, then back down to a lower power as the atmospheric steadiness is not sufficient to support high powers at the time you are observing. Keep in mind that a bright, clearly resolved but smaller image will show far more detail than a dimmer, poorly resolved larger image. Eyepieces of 20mm and 25mm focal length provide a wide field of view, ideal for general astronomical observing of star fields, clusters of stars, nebulae and galaxies. They are probably the best eyepieces to use in the initial finding and centring of any object.

● Once centered, the object can be focused by turning one of the knobs of the focusing mechanism. You will notice that the astronomical object in the field of view will begin to slowly move across the eyepiece field. This motion is caused by the rotation of the Earth on its axis, although the planets and stars are for practical purposes fixed in their positions in the sky. The platform on which the telescope is sitting (the Earth) rotates once every 24 hours under these objects. To keep astronomical objects in the field of view of the polar aligned telescope, simply turn the R.A. slow motion control. These objects will appear to move through the field more rapidly at higher powers.

Note: The Declination slow motion control is only used for centring purposes, not for tracking.

● Avoid touching the eyepiece while looking through the telescope. Vibrations resulting from such contact will cause the image to move.

● You should allow a few minutes for your eyes to become dark adapted before attempting any serious astronomical observations. Use a red filtered flashlight to protect your night vision when reading star maps or inspecting the components of the telescope.

● Avoid setting up the telescope inside a room and observing through an open window (or worse still, a closed window). Images viewed in such a manner may appeared blurred or distorted due to a temperature difference between the inside and the outside air.

Get to know the sky...

Since the dawn of mankind there have been independent thinkers who have sought to understand the nature of the Universe and our relationship to it. It is perhaps the city or suburban observer who feels the call of the cosmos most intensely when he or she experiences the majesty of the night sky from a truly rural location for the very first time. Assuming that you have been overawed by a similar experience, how do you go about becoming an astronomer? Perhaps the first step should be a trip to your local library to find out where and when your local astronomical society meets. There are over a hundred such groups in the United Kingdom alone, so there is bound to be a town near you that has one.

Getting started: When we leave the cosy confines of the living room and enter the realm of the night we lose many of our everyday frames of reference when we look up at the broad expanse of the sky. Familiar visual clues to judge size and distance are useless against the starry background where everything is so exceedingly remote as to be an infinite distance away. In fact, it is convenient to imagine the stars as being fixed upon the inside surface of a vast hemisphere, or dome, of infinite radius centred on your location - this concept is known as the celestial sphere, and it must be said that from a pitch-black location the heavens do, indeed, appear to be an enormous dome above our heads and resting on the horizon.

Over the years astronomers have conveniently divided up the celestial sphere into grids much like that of the lines of latitude and longitude that crisscross a terrestrial globe, such that all objects in the sky can be given a precise coordinate for later reference. When you become more proficient in your observing you will refer to detailed "road maps" of the stars that will use these very coordinate systems, but for now you need not worry about them. Star charts are of little use to the novice since many are confusingly covered with lines, labels which frequently fail to give any indication as to how large a constellation (or star group) will appear to the naked eye.

Joining the dots... : If you were good at seeing the pictures in those dotty puzzles that we used to draw around as a child, then you will have a distinct advantage when it comes to recognising and remembering constellation patterns! It is as well to note that the constellation outlines are entirely arbitrary – the familiar figures of Hercules, Leo and Orion are but three of the eighty-eight groups known to astronomers that are largely the result of the classicists' fertile imaginations. Note, too, that the stars of any given constellation are not necessarily associated with one another: they are in reality at greatly differing distances from us.

Finding that first constellation: A casual look at the moonless night sky, particularly from a rural location, will reveal so many thousands of stars that the absolute beginner will feel utterly lost and bewildered. However, the way to start is to locate a particularly prominent star pattern and use it as a starting point. For the winter observer there is no better celestial marker than the constellation of Orion, which straddles the celestial equator and is therefore visible from anywhere on the surface of the Earth.

Getting a sense of scale: Using a star chart from a monthly magazine that depicts the sky to the east in December you will get an impression of how large Orion appears in relation to the other constellations that border it, but just how big will it seem to the unaided eye? To get a sense of scale it is very convenient to use the outstretched hand at arms length as a convenient guide. You will discover that the distance from the tip of your little finger to that of your thumb will be just sufficient

to cover the seven principal stars that delineate the figure of Orion.

If we wish to be a little bolder we can relate the span of our outstretched hand to actual angular measure. It so happens that the span of our hand corresponds to just over 20 degrees (the symbol for degree is°), while the length of our thumb is about 7°. This latter figure conveniently matches the field of view of a low power pair of binoculars of the 7x50 or 8x30 variety (incidentally, all binoculars are labelled XX x YY, where XX is the magnification and YY is the diameter of the from lenses in millimetres).

The length of a thumb at arms length – 7°– it's not a great deal, is it? If you have a pair of binoculars then perhaps now you can appreciate just how small an area of sky is revealed to you at any one time, and why it can be a problem finding objects. Contrast this with the field of view of a typical astronomical telescope which is in the region of half a degree, or the apparent width of the Full Moon. It may surprise many of you to discover that the angular size of the Moon is so small (it can be covered by the equivalent of your little finger nail at arms length) – the proverbial man in the street would probably say that the Moon is as big as tennis ball or a small plate. If you don't believe me, try it!

Back to the constellations and naked eye viewing. Once we are confident that we have located, say, Orion (hint: the three so-called 'belt stars' at the centre of the pattern are the real giveaway), then we can use the figure as a stepping stone to the adjacent constellations. For example, just over a handspan above the belt of Orion brings you to the prominent orange star Aldebaran (pronounced 'Al-deh-bah-ran', which means "follower" in Arabic) in the constellation of Taurus, the Bull. With Orion's belt low to the south-east, we can move one and a half hand spans to the left parallel to the horizon to encounter the bright star Procyon (pronounced 'Pro-sigh-on') in the constellation of Canis Minor, the Lesser Dog. A further hand span to the upper left brings you to the celestial twins of Gemini, Castor and Pollux.

Another very familiar pattern visible throughout the year is the constellation of Ursa Major, or the Great Bear. Also known as the 'Plough' or the 'Big Dipper', the seven stars that comprise this easily identified pattern lie low to the northern horizon in winter months. Like Orion, the main part of this constellation subtends about the width of an outstretched hand at arms length. In this fashion you can use the prominent seasonal star groups as a kind of framework, then you can fill in the fainter constellations as your knowledge grows – and rest assured it will.

Broadening your horizons: Assuming that you feel confident in identifying the stars visible in any particular season, preferably with the help of members of your local astronomical society and the star charts of a magazine, then you may have already been introduced to the pleasures of binocular or telescopic astronomy. Having 'served your apprentiship', so to speak, you will be in a better position to appreciate the true potential of any given optical instrument. As was mentioned earlier, the art of observing is a skill to be acquired with constant practice, and in some individuals this faculty has been developed to an extraordinary degree such that they can perceive a celestial interloper such as a nova or comet at a glance.

Streetlights and light pollution: If you are fortunate to live in a rural area that is not plagued by streetlighting, then your view of the heavens will not be impaired. However, for the observer living in city or suburban areas the subtle phenomena of the skies are largely lost – this is why the clear, dark skies of country areas are such a revelation to many town dwellers: there is so much to see when the veil of light pollution has been lifted! So how can we alleviate the problem? Other than lobbying your Local Authority or private companies responsible, it is possible to invest in

special filters that can almost magically remove the orange cast to the sky created by sodium streetlights revealing a dark, star-studded sky beyond. These filters are not cheap – you can spend £100 quite easily for two for a pair of binoculars – but to the telescope user they are almost mandatory for any serious work concerned with hunting for galaxies and faint nebulae.

For the lunar and planetary observer, however, it is a very different story. The Moon is never impaired by the streetlight's glow (though the delicacy of earthshine on a very young crescent moon to the west shortly after sunset may be lost) and the bright planets such as Venus, Mars, Jupiter and Saturn may all be comfortably observed even from the heart of a city. One word of warning, though – if you have to set your telescope up on tarmac or concrete, especially after a warm day, the ground can reradiate absorbed heat after dark that causes a shimmering effect in the telescope, rather like looking through running water.

This rippling effect is caused by air currents circulating in and around the telescope that distorts the image. Always position a telescope outside for half an hour or so (security willing, of course) prior to commencing observing so that optics and conditions can settle down such that you will get the best views. Once you have a powerful telescope you will notice that the air is very unsettled on some nights, even after standing the telescope out for its cooling-off period. The fault then lies in the upper atmosphere and you will have to leave detailed planetary viewing to another night!

Photography: Sooner of later you will feel the desire to capture some of the beauty of the night sky on film to show to friends and relatives. You may be surprised to learn that an expensive camera and sophisticated drive system to follow the stars in the diurnal courses is not necessary in order to get very attractive pictures of the constellations: all that you need is a 35mm camera with a manual (or 'B' setting) setting, a standard 50mm lens, a fast colour (or B/W, it's up to you) film, tripod and cable release.

The film you will need can be print or transparency (slide), but you need to buy one with a speed of about ISO 400 (ASA). With a 50mm lens set to its widest aperture of f/1.4 or f/2 and focused at infinity we can capture stars fainter than those we can see with the naked eye over an area of sky that encompasses two spans of the outstretched hand at arms length, or about 40 degrees.

Since the camera is more sensitive than the eye to faint light, we have to very careful to set our camera and tripod well away from any direct street or security lighting - standing in the shade of a fence or wall will usually do the trick. It is also a good idea to tell members or your household that you are going out to do some astrophotography, so that the bathroom light does not come on unexpectedly, flooding your back garden with light and ruining your carefully obtained exposure!

One accessory that you will find immensely useful is a small flashlight fitted with a dim red bulb or a red filter over the lamp. The precious dark adaption that you gain through being in pitch blackness for a period of 15 minutes or more is less affected by red light than any other, so it is excellent for making notes or ensuring that you camera has been correctly set without ruining your night vision.

Taking the exposures: With your subject suitably framed within the viewfinder (all but the brighter stars will be difficult to see with the screen of some SLR cameras) make sure that the lens of the camera is wide open, the distance scale set to infinity and the cable release is firmly screwed in. With the palm of your hand held covering the lens (but NOT touching the camera), open the shutter with the cable release and lock it. Now briskly move your hand to one side to start the exposure without jogging the camera - this technique is

a simple way to avoid camera shake which ruins many a time exposure.

So how long should you leave the lens uncovered? Under dark skies with ISO 400 film and a 50mm f/2.8 lens you can expose for up to about 20 seconds before the motion of the stars becomes evident as small trails on the film. However, if the sky is exceptionally dark and the camera is pointed toward the north, especially in the vicinity of the Pole Star, Polaris, then you may take exposures up to two minutes or more since the diurnal motion of the stars are much less pronounced there. To finish the exposure, place your palm in front of the lens (again without jogging the camera) and unlock the cable release.

If you are feeling artistic then it always pays to have some foreground subject to 'frame' the stars. A gnarled old Oak tree devoid of leaves with its 'fingers' stretching to the sky would make a good silhouette for an atmospheric picture! A word about processing: with the advent of the high street 1 hour processing booth you can get very quick results with print films that use the C41 process. But do make sure that the technician knows that your subject matter is astronomical since it is very frustrating to return to pick up your hard-earned snaps only to be told that the roll was unexposed - they're just not used to seeing tiny white dots! Just tell them to print all frames regardless. If you can intersperse the pictures with everyday terrestrial scenes then so much the better, since this makes it easier for them to note the edge of a frame - nothing is more infuriating than an otherwise perfect night sky scene negative that has been carelessly cut in half.

With practice you will be able to photograph scenes of great beauty, especially if you have used colour film to capture the myriad colours of the stars. You may notice, too, that you have photographed things that you didn't notice at the time, like the streak of a meteor as it burned up in our atmosphere in a flash of incandescence or the longer trail of an artificial satellite as passed through the camera's field of view. Rarer sights such as moonbows and aurorae may also be captured by the attentive astrophotographer armed with no more than their tripod mounted camera.

CLEANING

As with any quality optical instrument, lens or mirror surfaces should be cleaned as infrequently as possible. Front surface aluminised mirrors, in particular, should only be cleaned when absolutely necessary. In all cases avoid touching any mirror surface. A little dust on the surface of a mirror or lens causes negligible loss of performance and should not be considered reason to clean the surface. When lens or mirror cleaning does become necessary, use a soft camel-hair brush or compressed air to gently remove the dust. If a telescope's dust cover is replaced after each observing session, cleaning of the optics will seldom be required.